3D Maps – from geometry to semantics
(and the application thereof)

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Part I

map generation:
*a step towards environment understanding*
On Mapping...

• Localization within a given map: ✔
  Mapping in case of stable localization: ✔
  Neither a-priori map nor localization is given: ❌

• Solution:
  **SLAM** *(simultaneous localization and mapping)*
  *[CML (concurrent mapping and localization)]*

• Generally based on:
  Scan registration
Scan registration

Iterative Closest Point (ICP) algorithm

• For prior point set $M$ (“model set”) and “data set” $D$:
  1. Select point correspondences $w_{i,j}$ in $\{0,1\}$
  2. Iteratively minimize for rotation $R$, translation $t$

\[
E(R, t) = \sum_{i=1}^{N_m} \sum_{j=1}^{N_d} w_{i,j} \left\| m_i - (Rd_j + t) \right\|^2
\]

  3. transform $D$, back to 1., until convergence

• works in 3 translation plus 3 rotation dimensions (6 DoF)
• registration of 2 3D scans with 100,000 points: 1 sec
Scan registration (example)
Constraint network – idea in 2D
Globally consistent 3D maps

- Extension to 3D
- Allows arbitrary graph topology
- Edges: weighed by covariance
- Innovation price for free software
Example of a global optimization – poses
Example of a global optimization – scans
Part II

industry application / system development
System: MEYER WERFT
System: MEYER WERFT
System: Robocup Rescue
Further applications

(in charge: Thomas Wiemann)
Part III

adding semantics...
# From sensor data to semantic maps

<table>
<thead>
<tr>
<th>3D</th>
<th>Sensordaten</th>
<th>syntaktische Merkmale</th>
<th>semantische Merkmale</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="3D Sensor Data" /></td>
<td><img src="image2.png" alt="3D Syntactic Features" /></td>
<td><img src="image3.png" alt="3D Semantic Features" /></td>
<td></td>
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(from: *Mobile Roboter – Eine Einführung aus Sicht der Informatik*. Joachim Hertzberg, Kai Lingemann, Andreas Nüchter)
(in charge: Sven Albrecht)
Part IV

further development / current projects
Further developments in our group:

- Object recognition (many projects, mostly agriculture use-cases)
- Localization + map building
  - Search & Rescue, incl. SLAM (research & industry)
  - Long term autonomy (e.g., a robot on a field)
- Planning & Reasoning (projects that require some kind of "understanding" of the environment)
Some current projects from that realm...